SHELL PUGET SOUND REFINERY PROCESS DESCRIPTION

The Shell Oil Products, North America (Shell) refinery in Anacortes, Washington (Shell) is located on March Point in the Puget Sound, approximately 12 miles west of Burlington, Washington. The refinery processes crude oil (crude) from central and western Canada delivered by pipeline, and Alaskan North Slope crude delivered by tanker. Products include gasoline and gasoline blend stocks, diesel, fuel oil, propane, butane, petroleum coke, sulfur, and nonene. The Shell Refinery includes the following processing areas: a crude distillation unit, a delayed coking unit, a fluid catalytic cracking/gas recovery unit, a polymerization unit, alkylation units (Alky 1 and 2), hydrotreaters (units HTU1, HTU2, and HTU3), catalytic reformers (units CRU1 and CRU2), and two sulfur recovery units. Other ancillary areas onsite include: a flare system (which includes three flares - east, north, and south and a flare recovery unit), a co-generation and boiler house facility, a product tank farm, a railcar loading station, and a wastewater treatment facility (effluent plant). The refinery can process up to 145,000 barrels of oil per day.

The crude unit separates the crude oil into fractions of specific boiling ranges by distillation and steam stripping. The lighter fractions or products can undergo further processing, or, in some cases, can be used as blending stocks. The heavier products, such as the gas oils, are sent to the fluidized catalytic cracking unit (FCCU) as feed stock. The vacuum residuum is sent to the delayed coking unit (DCU) as feed stock or it can be blended into No. 6 fuel oil.

In the DCU, the vacuum residuum is heated and then thermally cracked in one of two coke drums. The vapors from the coke drum are then charged to the fractionator while the coke remains in the coke drum. The fractionator then separates these vapors into fractions of specific boiling ranges by fractionation and steam stripping. The lighter fractions or products undergo further processing and then are sent to various units within the refinery. The coke is removed from the drum and recovered. The coke is then sent out by railcar or by truck to ships and barges. Effluent plant dissolved nitrogen flotation (DNF) float material may be injected into the off-stream coke drum during steam stripping.

The FCCU is used to convert heavy oils into a wide boiling range material from which lower molecular weight products such as naphtha and middle distillates are fractionated by distillation. The feed stock is generally a heavy distillate or gas oil with a boiling range of about 500 to 1,000 degrees Fahrenheit (°F). The FCCU consists of a catalyst section and a fractionation section that operate together as an integrated processing unit. The carbon monoxide (CO) boilers convert water to 600 pounds per square inch gauge (psig) steam by running boiler feed water through several tubes that are exposed to heat generated by large fired boilers. After the steam is generated, it is distributed throughout the refinery. The wet gas scrubber removes sulfur dioxide (SO_2) and catalyst fines from the CO boiler flue gas by contacting it with a dilute caustic solution.

The slurry purge stream is treated to remove catalyst fines in the clarifier and gravity flow bins, and receives further pre-treatment before it is discharged to the effluent plant.

Three flares (east, north, and south) that are tied together provide over-pressure and upset protection for all units. Under normal operating conditions, all flare gasses are routed through the flare gas recovery (FGR) unit. The flare gasses are compressed with five liquid ring compressors. The flare gasses then are processed through an amine absorber tower to remover hydrogen sulfide (H_2S) from the gas stream. The gas stream from the overhead of the amine absorber is routed to the plant fuel gas system or to the plant flares. Under high-pressure conditions, vented gasses are pushed through water seals in the seal pots and are burned at the flare tips. Steam is applied to the flare tips.

The catalytic reforming units (CRU1 and CRU2) convert low-octane naphthas (gasoline) into high-octane gasoline blending stocks. The naphtha feed is mixed with hydrogen and passed through a series of alternating furnaces and fixed-bed reactors containing a platinum bimetallic catalyst. The reactor effluent is sent to a separator, where the pressure is reduced and the mixture cooled to flash off the hydrogen. A portion of the hydrogen is recycled back to the CRU1 and CRU2 reactors, and the rest is sent to the hydrotreating units (HTU1, HTU2, and HTU3) for use in the hydrotreating reactors. The higher molecular weight products are removed from the bottom of the separator and further fractionated into fuel gas, liquified petroleum gas (LPG), and platformate (gasoline blending stock).

The HTU1, HTU2, and HTU3 remove nitrogen and sulfur compounds from the feed stock. The resulting hydrotreated products are a feed stock for the CRUs and a low-sulfur diesel fuel.

In the alkylation units (Alky 1 and 2), propylene and another byproduct of the FCCU called butylene are mixed with isobutane and a sulfuric acid catalyst. The sulfuric acid is removed, and the remaining product is pumped to distillation towers, where it is separated into LPG, mixed butanes, and alkylate, a high-octane blending component used in lead-free premium gasolines. Spent sulfuric acid from this process is sent off-site for regeneration.

In the polymerization unit, propylene – a byproduct of the cracking in the DCU and FCCU – is exposed to phosphoric acid-impregnated catalyst pellets. This process re-forms it into polymer gasoline, used to help blend gasoline, as well as nonene, a feedstock for making petrochemicals.

Light straight run material from HTU2 is fed to the isomerization (isom) unit, where a catalyst is used to help convert the straight-chain hydrocarbons into branched-chain hydrocarbons, increasing the octane levels. The product from the isom unit (isomerate) is blended into gasoline for off-site sales.

The nonene unit processes the polymer gasoline stream to produce nonene and tetramer. These two products go into separate storage tanks before sale to off-site customers. The polymer gasoline with the nonene and tetramer removed is sent to storage for blending into gasoline.

Shell operates two sulfur recovery units. In the sulfur recovery units, controlled combustion and then a catalyst are used to liquefy and remove the sulfur, which helps reduce emissions and allows the refinery to process this type of crude oil. The liquid sulfur is sold as a fertilizer ingredient.

Wastewater is treated at the on-site wastewater treatment facility, which is designated as the effluent plant. The wastewater is discharged under National Pollutant Discharge Elimination System (NPDES) permit No. WA-000294-1 to Fidalgo Bay. Effluent plant processes consist of primary oil removal, secondary biological treatment, and final disinfection. The plant typically processes 3 to 4 million gallons of wastewater per day. The effluent plant receives wastewater from two sources: the oily water sewer system and the stormwater sewer system. The effluent plant also handles ballast water from ships and transfers of off-specification products.

The oily water system receives process wastewater from numerous processes; the main sources are: crude unit desalters, sour water strippers, wet gas scrubber, cooling water tower blowdowns, Alky 2 weak acid sump, boiler house desilicizer regeneration, water draws from tanks, and process area stormwater. The oily water sewer enters the effluent plant at the American Petroleum Institute (API) oil-water separator (API), where floating oil and heavy solids are removed. The recovered oils are sent to slop oil tanks (currently, tank 60 is being used), and is recycled back into the refinery. Solids are physically removed from the bottom of the API by vacuum truck and shipped off-site as hazardous waste. The API has three bays that operated in parallel, and weirs are located at the exit of the API. The normal discharge flow from the API is sent to the dissolved nitrogen floatation (DNF) units for secondary oil and solids removal. Excess flow from the API is routed to the surge tanks. Two 3,600,000-gallon surge tanks (tanks 72 and 73) are used to store excess flows. Also, any wastewaters that may harm the treatment system can be diverted to the surge tanks.

The three DNF units are known as the north, south, and 3rd DNF units. The DNF units are operated in parallel. The skimmed DNF float material is pumped to tank 61 for storage. In the past, the DNF float material was taken to tank 206 and then processed in the coke drum. Tank 206 has been out of service for a few years, so the DNF float material is currently stored in tanks 61, 70, and 71. Wastewater discharged from the DNF units is pumped to the biological treatment section.

Biological treatment process units include a closed biological pre-treatment tank (tank 74), an oxidation channel bioreactor system, two gravity clarifiers, two aerobic digesters, and the south retention pond. The biomass solids from the digesters are placed into large dewatering bags. The bags are taken to the closed landfarm area and stored. While they are being stored, the bags dewater to the oily water sewer, under an agreement with the state. The biomass solids have been determined to be a non-hazardous waste. Oxygen is added at the south retention pond, and additional biomass solids settle out. To chlorinate the wastewater, sodium hypochlorite is added at the outlet of the south retention pond. Wastewater flows from the south retention pond to the final pond, where stormwater and treated effluent are tested prior to their discharge to Fidalgo Bay.

The stormwater system receives stormwater from non-process areas of the refinery. The stormwater sewer enters the effluent plant at the storm surge basin and then flows to the clean water flume. The clean water flume discharges to the final pond. The purpose of treating the stormwater is to remove solids before the stormwater is mixed with flow from the process side of the system in the final pond prior to discharge to the bay.

The north and south overflow basins are used for emergency spill containment for the surge tanks, and may also be used to store excess treated final pond wastewater.